Bioremediation Through The Use of Indigenous Natural Resources vis-a-vis Its Impact on Morphology, Metabolism, Yield, Soil Health and Soil Biodiversity of Paddy Field Under Fluoride Toxicity

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***Abstract*—** *An assessment was undertaken to study the combating capacity of bacterial consortia isolated from different sources viz. oil spillage sludge and water spillage of petrol pump and rhizosphere of rice plant against the fluoride toxicity under field condition. Oryza sativa was selected as a test species. The recommended doses of chemical fertilizers (70:35:35) and different concentration of sodium fluoride (25 , 50 , 100 , 200 , 300 , 400 and 500 mg Kg^{-1} F) were used for first set of experiment and the second set were treated with vermicompost, compost, bacterial consortia and different concentration of sodium fluoride(25 ; 50 , 100 , 200 , 300 , 400 and 500 mg Kg^{-1} F). Among all of the species Penicillium, Aspergillus and Fusarium were resistant and survived under fluoride polluted condition. One unique thing was observed from these experiment that paddy which were grown under indigenous organic inputs treated plots gave maximum yield under T_1 treatment (25 mg Kg^{-1} F) which was above the control set. Moreover, stress enduring metabolites viz. proline content of flag leaves were lowest recorded under indigenous organic inputs treated plots as compared to chemical fertilizer treated plots. Data were significantly different at 5% level using Duncan's Multiple Range Test. From the Air Pollution Tolerance Index (APTI) value of paddy clearly depicted that the crop of those plots were treated with indigenous organic inputs were more resistant for enduring stress condition. In these experiment combination of vermicompost, compost and bacterial consortia were capable of reducing the amount of fluoride within plant parts especially in grains (< 0.3 mg Kg^{-1} as recommended by EPA, FAO and WHO), where fluoride was within permissible range as well as they reduced the fluoride content within the soil (2.57-16.44 mg Kg^{-1}. as recommended by FAO, EPA, and WHO) as was noted by measuring the fluoride in the plant parts and soil after the experiment. Therefore, bacterial consortia could be an alternative for bioremediation of fluoride.*

Keywords*— *APTI, Fluoride, Oil spilled site, Stress enduring metabolites, Vermicompost.

I. INTRODUCTION

Fluorine is a chemical element with symbol F and atomic number 9. It is the lightest halogen and exists as a highly toxic pale yellow diatomic gas at standard conditions. As the most electronegative element, it is extremely reactive, almost all other elements including some noble gases form compounds with fluorine. Among the elements, fluorine ranks 24th universal abundance and 13th in terrestrial abundance. Now a day's, fluoride (F) is a most concerned environmental pollutant which is a toxic substance, present in air, water and soil. The toxic effects of F on plants and animals have been known for more than a hundred years. With recent industrial expansion they have been increasingly recognized for causing serious toxicity to vegetation (Dey et al., 2012). There are numerous papers regarding the impact of fluoride on ground water, soil and biochemical changes of different plants under laboratory condition. But, very few limited number of works have been reported about the amelioration of fluoride under the field condition.

F is a naturally occurring pollutant, which is often released into the soil-environment through the use of phosphatic fertilizers and other pesticidal sprays as well as through the disposal of industrial sludges (Singh et al., 1990).

Fluorine content in different soil is determined by its concentration in a parent material, while its distribution in soil profile depends on the rate of mineral decomposition, pH and content of the clay fraction (Omueti and Jones, 1980). Damage caused by fluorine in soil is connected mainly with the destabilization of natural soil structure due to changes of the soil humus-silt complex, and also mineral composition. The presence of alkaline metal fluorides decreases the content of organic matter soluble in water, also the mobility of mineral-organic complexes. As result of such changes the biological activity of soil can be decreased. Due to such detrimental effects growth and activity of microorganisms are present in soil become decreased.

In case of plant/ crop species they can uptake fluoride from the soil as a free ion or it can enter into the plant body through the stomata from the air (Stevens et al., 1997; Mezghani et al., 2005). Sodium fluoride inhibit germination, cause ultra structure malformations, reduce photosynthetic capacities, alter membrane permeability, reduce productivity, decrease biomass and inflict other physiological and biochemical disorders in plants(Gautam et al., 2010). Moreover, F toxicity may have important consequences such as reduction in growth or yield (Singh et al., 2013).

To find out the impact of fluoride on growth, metabolism and yield of crops *viz.* paddy as well as ameliorating capability of indigenous organic inputs under field condition, one field experiment was carried out in the year 2013. From the experiments one unique thing was revealed i.e., the bioremediation measure of fluoride under field condition may be possible. Such bioremediation measures were mixture of vermicompost, compost (cow dung) and bacterial consortia isolated from different sources such as rhizospheric soil, oil spillage sludge and wastewater of petrol pump vicinity. Such type of indigenous organic resources are chosen as a bioremediation measure because there are some limitation or drawback in traditional agriculture practice *viz.* decline soil productivity, loss of organic matter, water holding capacity and biological activity. Traditional agriculture practice involved use of various kind of chemical fertilizers, pesticides etc. Use of chemical fertilizers contaminates soil and water bodies, such as lakes and rivers. Pesticides may kill the insects that destroy crops, but they also kill the good insects as well. To overcome such type of problems in recent year's scientists and engineers started to generate cost effective technologies which includes use of microorganisms/biomass or live plants for cleaning of polluted areas (Qiu et al., 2006). It was well documented that above mentioned organic indigenous inputs having potentiality to combat against stress condition as well as reduce the uptake and transportation of toxic metals through the plant system (Jadia and Fulekar, 2008). Application of compost and vermicompost in contaminated soil improves soil fertility and physical properties as well as helps in successful approach to phytoremediation (Zheljazkov and Warman, 2004). It also enhances the quality of growing plants and increased biomass which could suggest that more metal taken up from the contaminated growth media and the tolerance to the metal toxicity is improved(Tang et al., 2003). It has been found to influence all growth and yield parameters such as improved seed germination, enhanced rate of seedling growth, flowering and fruiting of major crops like wheat, paddy, spinach, corn, tomato etc. Earthworms consume large quantities of organic mater and excrete it as cast and this cast contains several enzymes and is rich in plant nutrients which are beneficial for bacteria and mycorrhizae (Reddy and Reddi, 2002). They also noted that vermicompost is an excellent base for the establishment of beneficial non-symbiotic and symbiotic microbes. Application of vermicompost increases total microbial population of nitrogen-fixing bacteria and actinomycetes (Garai et al., 2013).

Bacterial consortium are assemblages of different species of microbes in physical (and sometimes intricate biochemical) contact with one another. These bacteria are capable of fixing atmospheric nitrogen, solubilize phosphorous and iron and enhance production of plant hormones. Additionally they improve the plant tolerance to stresses (Bashan et al., 2008; Chan, 2003).

II. MATERIALS AND METHODS

2.1 Experimental Site

Field studies was conducted at Crop research and Seed Multiplication Farm, Burdwan University, Burdwan, West Bengal (Figure 1) which is located at 87 º 50' 37.35" E latitude and 23 º 15' 7.29" N longitude with an average altitude at 30 meter above sea level during the rainy season on 2013 with paddy (*Oryza sativa* cv. MTU 5720).

FIGURE 1: EXPERIMENTAL SITE

2.2 Climatic condition

The field experiment conducted in randomized block design with three replicas for each treatment. The minimum and maximum relative humidity and temperature of this area recorded during the growth period were 84 % to 98 % and 22.02ºC to 34.9ºC, respectively. Average wind speed (1.5-7.4 Km/hr) and mean sunshine (3.03 to 7.29 hr) were recorded. Maximum rainfall was found on September 2013 (175.6 mm).

2.3 Field Preparation

Field was prepared on and from 26th july 2013. Recommended doses of fertilizer , (70:35:35, Directorate of Agriculture, Government of West Bengal for mustard) were used in the form of urea, single super phosphate (SSP) and mureate of potash (MOP), vermicompost and compost were sprayed within the field on 27th July, 2013. Different doses of sodium fluoride were sprayed on 30th July, 2013. After that for the first part of experiment (24 subplots) paddy seedlings were transplanted on 2nd August, 2013 and for another 24 subplots paddy seedlings which were treated with bacterial consortia(root dipping) were also transplanted on the same day. Two hand-weedings on 15-18 DAT and 38-40 DAT were carried out. Crop was irrigated with the tap water of Crop research and Seed Multiplication Farm of Burdwan University, Burdwan, West Bengal through pipe as and when it was needed. Crop was harvested separately on 3rd October, 2013 and kept for 2-3 days for sun drying.

2.4 Treatment combination and design

The experiments were conducted in randomized block design. The plot size was 2.5×2.5 mt^2 .Row to row and plant to plant spacing was 1.5 mt and 15 cm, respectively. Irrigation channels measuring 1.0 m wide were in between the replications to ensure easy and uninterrupted flow of irrigation for each individual plot. Experimental plot was divided into 6 main plots and 48 subplots (Each plot had three replicas). Under 24 subplots, soils were treated with recommended doses of chemical fertilizer and different concentration of sodium fluoride such as 25, 50, 100, 200, 300, 400 and 500 mg Kg^{-1} fluoride . Another 24 subplots were treated with vermicompost, compost along with same concentration of fluoride, vermicompost and compost. Root of seedlings was dipped with bacterial consortium for few hour. The bacterial consortia were isolated from rhizosphere of rice plant and soil and water of oil spillage in a petrol pump. The treatment groups were designed as

2.4.1 First Set

T_1= Recommended dose of chemical fertilizers (70:35:35) +25 mg Kg-^{1} fluoride +Seedlings
T_2= Recommended dose of chemical fertilizers (70:35:35) +50 mg Kg^{-1} fluoride + Seedlings
T_3= Recommended dose of chemical fertilizers (70:35:35) +100 mg/Kg-^{1} fluoride +Seedlings
T_4= Recommended dose of chemical fertilizers (70:35:35) +200 mg/Kg^{-1} fluoride +Seedlings
T_5 (Control**) =** Recommended dose of chemical fertilizers (70:35:35) + Seedlings
T_6= Recommended dose of chemical fertilizers (70:35:35) +300 mg Kg^{-1} fluoride +Seedlings
T_7= Recommended dose of chemical fertilizers (70:35:35) +400 mg Kg^{-1} fluoride +Seedlings
$T_{8=}$ Recommended dose of chemical fertilizers (70:35:35) +500 mg Kg-^{1} fluoride +Seedlings

2.4.2 Second Set

$T_{1=}$ Vermicompost (full dose i.e., 1.5 Kg plot^{-1}) + Compost (full dose i.e., 1.5 Kg plot^{-1}) +25 mg Kg^{-1} fluoride +bacterial consortia treated seedlings
T_2= Vermicompost (full dose i.e., 1.5 Kg plot^{-1}) + Compost full dose i.e., 1.5 Kg plot^{-1}) +50 mg Kg^{-1} fluoride +bacterial consortia treated seedlings
T_3= Vermicompost (full dose i.e., 1.5 Kg plot^{-1}) + Compost (full dose i.e., 1.5 Kg plot^{-1}) +100 mg Kg^{-1} fluoride +bacterial consortia treated seedlings
T_4= Vermicompost (full dose i.e., 1.5 Kg plot^{-1}) + Compost (full dose i.e., 1.5 Kg plot^{-1}) +200 mg Kg^{-1} fluoride +bacterial consortia treated seedlings
T_5 (Control**) =** Vermicompost (full dose i.e., 1.5 Kg plot^{-1}) + Compost (full dose i.e., 1.5 Kg plot^{-1}) +bacterial consortia treated seedlings
T_6= Vermicompost (full dose i.e., 1.5 Kg plot^{-1}) + Compost (full dose i.e., 1.5 Kg plot^{-1}) +300 mg Kg^{-1} fluoride +bacterial consortia treated seedlings
T_7= Vermicompost (full dose i.e., 1.5 Kg plot^{-1}) + Compost (full dose i.e., 1.5 Kg plot^{-1}) +400 mg Kg^{-1} fluoride +bacterial consortia treated seedlings

$T_{8=}$ Vermicompost (full dose i.e., 1.5 Kg plot^{-1}) + Compost (full dose i.e., 1.5 Kg plot^{-1}) +500 mg Kg-1 fluoride +bacterial consortia treated seedlings

2.5 Data collection

The physical, chemical and biological properties of the initial experimental soil and chemical and biological properties of vermicompost and cow dung have been represented in the Tables 1, 2 and 3.

TABLE 1
PHYSICAL, CHEMICAL AND BIOLOGICAL CHARACTERISTICS OF EXPERIMENTAL SOIL (0-15 cm DEPTH)

Characteristics	Value
Sand (0.02-0.2 mm)(%) Silt (0.002-0.02 mm)(%) Clay (<0.002 mm) (%)	39.84±0.015 17.67±1.528 41.16±0.015
Moisture Content (%)	5.628±0.001
Bulk density(g cc^{-1})	0.72±0.001
Particle density(g cc^{-1})	2.398±0.002
Porosity (%)	69.97±0.015
pH	5.43±0.036
EC(ms cm^{-1})	0.04±0.001
Organic matter (%)	3.16±0.001
Available N (Kg ha^{-1})	12.992±0.001
Available P (Kg ha^{-1})	115.230±0.001
Available K (Kg ha^{-1})	209.722±0.540
Available Ca(meq 100g^{-1}) Available Mg(meq 100g^{-1})	0.53±0.001 0.293±0.006
DTPA extractable Zn(ppm)	0.503±0.015
DTPA ectractable Cu (ppm)	2.033±0.153
DTPA extractable Mn (ppm)	8.167±0.153
DTPA extractable Fe(ppm)	23.007 ±0.015
Fluoride (ppm)	0.137±0.006
Total Bacteria(CFU g^{-1} of soil)	41x10^{6}
Total Fungi CFU g^{-1} of soil)	28 x10^{3}

TABLE 2
CHEMICAL AND BIOLOGICAL CHARACTERISTICS OF VERMICOMPOST

Available Nitrogen (%)	Available Phosphorous (%)	Available Potassium (%)	Total bacteria (CFU g^{-1})	Total fungi (CFU g^{-1})
1.4±0.1	1.17±0.01	0.99± 0.01	61.33 x10^{6}	32.33 x10^{3}

TABLE 3
CHEMICAL AND BIOLOGICAL CHARACTERISTICS OF COMPOST (COWDUNG)

Available Nitrogen (%)	Available Phosphorous (%)	Available Potassium (%)	Total bacteria (CFU g^{-1})	Total fungi (CFU g^{-1})
0.97±0.01	1.02±0.015	0.54± 0.015	33.33 x10^{6}	22.33 x10^{3}

2.6 Parameter studied

On 30, 45 and 60 DAT (Days after Transplanting) following morpho-physiological parameters i.e., root length, shoot length, fresh weight, dry weight and leaf area index (Watson, 1952) were measured.

$$LAI= \frac{\text{Total leaf area of 'n' number plants x plant population/m}^2}{\text{'n' number of plants}}$$

After 30, 45 and 60 DAT(Days After Interval) interval biochemical parameters such as chlorophyll (Arnon, 1949); proline (Bates et al., 1973) and total soluble sugar (Mc.Cready et al., 1950) were measured by standard methods.

Number of tiller per hill, length of panicles, weight of panicles, number of panicles per hill, number of chaffy grains per panicles, number of filled grains per panicles, grain yield and straw yield were measured. Crops from each plot were harvested, tied in bundles, dried and then taken to the threshing floor for threshing. After threshing, the grains were cleaned, sun-dried and their weights were recorded. The yields in g m^{-2} were converted to Kg ha^{-1}.Apart from this straw weight was recorded.

Though the experimental site is not located within the air pollution zone but the crop species grown under stressed condition therefore APTI values (Mashitha and Pise, 2001) were recorded to see whether the crop species sensitive or not. For this index following parameters such as ascorbic acid according to Thimmaiah, 1999, leaf pH (Singh and Rao, 1983), total chlorophyll (Arnon, 1949) and Relative Water Content(%) (Barrs and Weatherley, 1962) were estimated.

$$APTI = \frac{A(T+P)+R}{10}$$

A=Ascorbic acid (mg/100g); T=Total chlorophyll; P=pH; R=Relative Water Content (%).

Beside these photosynthetic rate was measured directly through LICOR (6400 XT).Fluoride accumulation in different parts of paddy were estimated by digestion method (Paul et al., 2011) and measured its quantity through ion selective electrode (ORION STAR A 214 pH/ISE meter).

Soil physical parameters such as soil texture was determined by hydrometer method, moisture content % (Saxena, 1998), Bulk density (Gupta, 2004), Particle density (Black, 1965) and Porocity (%) (Black, 1965) were determined according to above mentioned standardised method.

Soil pH (Jackson, 1972) and electrical conductivity (Trivedy and Goel, 1998) were measured by pH meter (Eutech pH.700) and conductivity meter (Systronics, Model No.335). Available N was measured by the alkaline permanganate method (Subbiah and Asija, 1956). Available P was extracted by sodium bi carbonate according to Olsen et al., (1954). Available K was extracted by 1 M ammonium acetate (pH = 7.0) and was determined by flame photometry (Black, 1965). Soil organic carbon was determined using the wet digestion method of Walkely and Black, (1934). Available micronutrients were extracted by diethylenetriamine pentaacetic acid (DTPA) (Lindsay and Norvell, 1978), followed by atomic absorption spectorphotometry (PerkinElmer 200AA, Perkin Elmer Inc., Waltham,MA, USA). Available exchangeable calcium and magnesium were measured by titrimetric method with 0.01 (N) EDTA (Schwarzendach et al., 1946). Fluoride were estimated from different vertical soil layer i.e., surface soil, 10 cm and 20 cm (Lori, 1987) and measured its quantity through ion selective electrode (ORION STAR A 214 pH/ISE meter).

Bacterial and fungal population from different treatment soil including control (pre and post harvested soil) were enumerated, counted by standard plate count (Aneja, 2002) from this colony count CFU g^{-1} or colony forming unit was calculated as well as identification ,especially fungi were done through staining method with cotton blue and lacto phenol mixture.

2.7 Statistical calculation

Duncan's multiple range test (DMRT) (Gomez and Gomez, 1984) at 5 % confidence interval was done with MINITAB software package (version 16) (http://www.minitab.com) and LSD at 5%, SEM (±) and CV% were performed to study the significance of different fluoride concentration on different parameters studied.

III. RESULTS AND DISCUSSION

3.1 Crop Morpho-physiological attributes

Present results highlighted that the root length, plant height, fresh weight, dry weight of root, shoot and leaves, of paddy grown under vermicompost, compost, bacterial consortia and different concentration of sodium fluoride treated plots were recorded highest with T_1 treatment (25 mg Kg^{-1} fluoride). The value is above the value of control set (Raja et al., 2006; Zeats et al., 2010; Rajasekar and Elango, 2011; Khan and Ishaq, 2011; Sharma et al., 2014). Lowest values were recorded with T_8 (500mg Kg^{-1} fluoride) (Table 4 and 5).

TABLE 4
IMPACT OF CHEMICAL FERTILIZER AND FLUORIDE ON MORPHO-PHYSIOLOGICAL ATTRIBUTES OF PADDY

Treatments (mg Kg^{-1} F)	Root length (cm)	Plant Height (cm)	FW (root) (g)	FW (shoot) (g)	FW (leaves) (g)	DW (root) (g)	Dw (shoot) (g)	DW (leaves) (g)
Control(T_5)	21.35^{a} 16.80^{a} 19.10^{a}	39.13^{a} 48.71^{a} 64.45^{a}	46.00^{a} 35.34^{a} 45.91^{a}	64.95^{a} 91.61^{a} 116.54^{a}	10.187^{a} 14.12^{a} 17.93^{a}	5.159^{a} 6.155^{a} 9.616^{a}	18.62^{a} 19.05^{a} 24.64^{a}	13.737^{a} 13.980^{a} 14.985^{a}
T_1	18.00^{a} 15.58^{a} 17.10^{a}	38.96^{a} 48.69^{a} 60.14^{ab}	43.40^{a} 30.02^{ab} 44.76^{a}	39.03^{b} 64.97^{b} 89.96^{b}	9.917^{a} 12.27^{ab} 16.50^{a}	3.147^{b} 5.175^{b} 7.172^{b}	18.26^{b} 18.56^{b} 19.93^{b}	4.650^{b} 4.787^{b} 5.736^{b}
T_2	17.74^{a} 14.73^{a} 16.70^{a}	37.09^{a} 44.95^{ab} 59.71^{ab}	34.65^{a} 27.98^{abc} 44.10^{a}	30.47^{c} 54.91^{c} 80.94^{c}	9.484^{a} 10.89^{ab} 15.05^{a}	3.139^{c} 5.156^{c} 7.063^{c}	17.41^{c} 17.54^{c} 18.07^{c}	4.553^{c} 4.747^{b} 5.242^{c}
T_3	17.52^{a} 14.35^{a} 16.60^{a}	34.10^{a} 44.06^{ab} 55.23^{abc}	33.89^{a} 24.58^{abc} 39.44^{ab}	29.59^{d} 54.66^{d} 79.61^{d}	9.297^{a} 10.45^{ab} 14.65^{a}	3.126^{d} 5.143^{d} 6.457^{d}	15.25^{d} 15.62^{d} 16.49^{d}	4.235^{d} 4.289^{c} 4.960^{d}
T_4	17.23^{a} 14.07^{a} 15.60^{a}	33.65^{a} 43.85^{ab} 51.01^{bcd}	24.55^{ab} 19.07^{bcd} 31.89^{abc}	27.60^{e} 53.56^{e} 79.61^{d}	7.406^{a} 9.80^{ab} 12.54^{a}	3.107^{e} 5.133^{e} 5.082^{e}	11.78^{e} 11.80^{e} 12.08^{e}	4.192^{d} 4.220^{c} 4.634^{e}
T_6	16.93^{a} 14.02^{a} 15.27^{a}	33.02^{a} 43.13^{ab} 43.07^{cd}	9.58^{b} 17.38^{cd} 17.67^{bc}	16.98^{f} 41.88^{f} 65.83^{e}	6.890^{a} 8.87^{ab} 11.56^{a}	2.396^{f} 4.390^{f} 2.807^{f}	3.99^{f} 4.04^{f} 5.02^{f}	3.242^{e} 3.391^{d} 3.665^{f}
T_7	16.67^{a} 14.01^{a} 15.18^{a}	32.61^{a} 38.09^{bc} 40.88^{d}	3.43^{b} 11.17^{d} 15.20^{c}	10.14^{g} 12.01^{f} 25.91^{f}	6.201^{a} 7.66^{b} 10.35^{a}	2.381^{g} 4.350^{g} 2.396^{g}	3.84^{g} 3.85^{g} 4.94^{g}	2.882^{f} 2.947^{e} 3.033^{g}
T_8	16.04^{a} 13.97^{a} 14.60^{a}	32.49^{a} 34.25^{c} 39.99^{d}	2.98^{b} 8.49^{d} 9.82^{c}	6.90^{h} 7.90^{h} 22.70^{g}	5.252^{a} 7.37^{b} 8.72^{a}	2.375^{h} 2.587^{h} 1.372^{h}	2.90^{h} 2.97^{h} 3.84^{h}	2.802^{g} 2.816^{f} 2.886^{h}
SEM(±)	0.963 0.711 1.145	1.361 1.324 2.323	3.882 2.177 3.961	0.182 0.065 0.002	0.984 1.006 1.856	0.001 0.003 0.003	0.028 0.023 0.016	0.016 0.030 0.002
LSD at 5%	5.057 3.735 6.018	7.150 6.955 12.20	20.39 11.44 38.7	0.610 0.217 0.005	5.168 5.286 9.750	0.005 0.009 0.010	0.095 0.076 0.053	0.054 0.099 0.006
CV (%)	16.3 14.5 21.1	11.6 9.2 13.4	46.9 30 20.81	0.9 0.2 0	36.5 29.7 41.5	0.1 0.1 0.1	0.3 0.3 0.2	0.4 0.8 0

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

Upper, middle and lower value indicates data of 30 DAT, 45 DAT and 60 DAT, DATdays after transplanting , FW Fresh Weight, DW Dry Weight, SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance

TABLE 5
IMPACT OF VERMICOMPOST, COMPOST, BACTERIAL CONSORTIUM AND FLUORIDE ON MORPHO-PHYSIOLOGICAL ATTRIBUTES OF PADDY

Treatments (mg Kg^{-1} F)	Root length (cm)	Plant Height (cm)	FW (root) (g)	FW (shoot) (g)	FW (leaves) (g)	DW (root) (g)	Dw (shoot) (g)	DW (leaves) (g)
Control(T_5)	18.27^{a} 15.45^{a} 13.93^{ab}	34.85^{a} 41.02^{a} 50.07^{bcd}	19.49^{ab} 23.41^{abc} 20.52^{bcd}	33.24^{b} 55.19^{abc} 61.51^{c}	7.452^{a} 9.91^{ab} 10.88^{ab}	4.571^{d} 5.219^{e} 5.450^{e}	15.63^{b} 19.59^{a} 22.49^{b}	2.887^{cd} 3.327^{b} 5.017^{e}
T_1	20.25^{a} 17.03^{a} 16.65^{a}	37.58^{a} 44.44^{a} 59.25^{a}	41.44^{a} 28.82^{a} 40.61^{a}	52.07^{a} 74.88^{a} 111.08^{a}	9.383^{a} 13.45^{a} 17.26^{a}	6.570^{a} 8.661^{a} 10.459^{a}	17.52^{a} 19.66^{a} 24.64^{a}	11.350^{a} 13.230^{a} 15.232^{a}
T_2	19.77^{a} 16.92^{a} 16.07^{ab}	36.57^{a} 43.04^{a} 57.05^{ab}	36.15^{a} 26.23^{ab} 32.00^{ab}	40.08^{ab} 66.72^{a} 100.49^{ab}	9.283^{a} 12.23^{ab} 12.83^{ab}	6.546^{a} 6.860^{b} 7.466^{b}	14.45^{c} 18.51^{b} 19.43^{c}	3.122^{b} 3.425^{b} 5.370^{b}
T_3	19.38^{a} 16.40^{a} 16.07^{ab}	35.69^{a} 42.18^{a} 54.84^{abc}	33.06^{a} 26.18^{ab} 26.64^{b}	38.13^{ab} 59.88^{a} 87.15^{b}	8.802^{a} 12.00^{ab} 11.79^{ab}	6.440^{b} 6.657^{c} 7.232^{c}	14.09^{d} 18.23^{c} 19.01^{d}	3.008^{bc} 3.409^{b} 5.481^{c}
T_4	18.50^{a} 16.37^{a} 14.40^{ab}	35.13^{a} 41.30^{a} 50.56^{bcd}	31.63^{a} 25.48^{ab} 24.92^{bc}	35.08^{b} 55.19^{ab} 80.72^{bc}	8.297^{a} 10.47^{ab} 11.76^{ab}	6.147^{c} 5.758^{d} 6.755^{d}	11.66^{e} 13.55^{d} 15.45^{e}	2.998^{bc} 3.408^{b} 5.194^{d}
T_6	18.27^{a} 15.23^{a} 13.57^{ab}	34.12^{a} 40.15^{a} 49.71^{bcd}	8.00^{b} 11.90^{bc} 12.62^{cd}	10.29^{c} 26.23^{bd} 37.05^{d}	4.592^{a} 9.460^{ab} 10.04^{b}	1.887^{e} 2.119^{f} 3.117^{f}	4.50^{f} 4.90^{e} 5.01^{f}	2.775^{d} 3.157^{c} 4.780^{f}
T_7	17.43^{a} 14.90^{a} 12.48^{b}	33.88^{a} 39.92^{a} 47.27^{cd}	7.71^{b} 11.73^{bc} 12.26^{cd}	8.07^{c} 25.56^{bd} 35.56^{d}	4.281^{a} 9.17^{ab} 9.74^{b}	1.776^{f} 2.000^{g} 2.586^{g}	4.11^{g} 4.29^{f} 4.93^{g}	2.590^{e} 2.947^{d} 3.471^{g}
T_8	16.13^{a} 13.88^{a} 12.45^{b}	33.14^{a} 39.92^{a} 46.17^{d}	5.89^{b} 10.20^{c} 9.97^{d}	7.86^{c} 23.40^{d} 31.14^{d}	4.268^{a} 7.88^{b} 7.81^{b}	1.005^{g} 1.122^{h} 1.481^{h}	2.99^{h} 3.10^{g} 3.84^{h}	2.499^{e} 2.885^{d} 3.014^{h}
SEM(±)	1.325 0.695 0.637	0.973 1.464 1.424	3.944 2.563 2.297	2.989 5.330 3.796	0.876 0.909 1.848	0.007 0.002 0.007	0.058 0.048 0.002	0.045 0.028 0.015
LSD at 5%	6.964 3.649 3.346	5.113 7.689 7.480	20.72 13.46 12.07	15.70 28.01 19.94	4.601 4.778 6.181	0.024 0.005 0.002	0.195 0.162 0.008	0.151 0.093 0.051
CV (%)	21.5 13.2 13.2	8.3 10.6 8.2	51.6 37.5 30.7	31.9 33.1 16.7	37.3 25.8 22.7	0.2 0 0.1	0.8 0.5 0	1.6 0.9 0.4

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

Upper, middle and lower value indicates data of 30 DAT, 45 DAT and 60 DAT, DAT days after transplanting , FW Fresh Weight, DW Dry Weight, SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance

Plant population, leaf area index of paddy grown under vermicompost, compost, bacterial consortia and different concentration of sodium fluoride treated plots were recorded highest with T_1 treatment (25 mg Kg^{-1} fluoride, Table 6). The value is above the value of control set (Raja et al., 2006; Zeats et al., 2010; Rajasekar and Elango, 2011; Khan and Ishaq, 2011; Sharma et al., 2014). Lowest values were recorded with T_8 (500mg Kg^{-1} fluoride, Table 6).

TABLE 6
COMPARATIVE STUDY BETWEEN TWO DIFFERENT TREATMENT COMBINATIONS ON LEAF AREA INDEX AND PLANT POPULATION OF PADDY

Treatments (mg Kg^{-1} F)	Plant Population (Chem+Fluoride)	Plant population (VC+Comp+BC+Fluoride)	LAI (Chem+Fluoride)	LAI (VC+Comp+BC+Fluoride)
Control (T_5)	73.41^{a}	73.00^{a}	2.336^{a} 2.445^{a} 2.945^{a}	2.317^{b} 2.585^{a} 3.140^{b}
T_1	72.84^{a}	73.70^{a}	2.255^{b} 2.420^{a} 2.670^{b}	2.327^{a} 2.605^{a} 3.215^{a}
T_2	72.13^{a}	70.67^{b}	2.240^{c} 2.370^{a} 2.595^{c}	2.304^{c} 2.485^{b} 3.125^{bc}
T_3	71.76^{a}	69.67^{b}	2.229^{d} 2.340^{a} 2.550^{cd}	2.282^{d} 2.445^{c} 3.095^{c}
T_4	69.41^{a}	68.00^{c}	2.225^{e} 2.315^{a} 2.495^{de}	2.268^{e} 2.380^{d} 2.875^{d}
T_6	62.41^{b}	47.34^{d}	2.220^{f} 2.295^{a} 2.440^{ef}	2.258^{f} 2.335^{e} 2.765^{e}
T_7	56.00^{c}	38.33^{e}	2.213^{g} 2.225^{a} 2.410^{f}	2.250^{f} 2.295^{f} 2.690^{f}
T_8	37.50^{d}	34.50^{f}	2.203^{h} 2.200^{a} 2.375^{f}	2.223^{g} 2.285^{f} 2.675^{f}
SEM(±)	1.295	0.385	0.001 0.093 0.021	0.003 0.006 0.013
LSD at 5%	4.331	1.289	0.003 0.310 0.069	0.009 0.021 0.043
CV (%)	2.8	0.9	0.1 5.6 1.1	0.2 0.4 0.6

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

Upper, middle and lower value indicates data of 30 DAT, 45 DAT and 60 DAT, DAS days after transplanting , FW Fresh Weight, DW Dry Weight, SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, LAI Leaf Area Index, Chem: Chemical fertilizer, VC: Vermicompost, Comp: Compost , BC: Bacterial Consortium

3.2 Biochemical attributes

Chlorophyll of paddy grown under vermicompost, compost, bacterial consortia and different concentration of sodium fluoride treated plots were recorded highest with T_1 (minimum) treatment (25 mg Kg^{-1} fluoride, Table 8). The value is above the value of control set (Raja et al., 2006; Zeats et al., 2010; Rajasekar and Elango, 2011; Khan and Ishaq, 2011 ; Sharma et al., 2014). Lowest values were recorded with T_8 (highest) (500mg Kg^{-1} fluoride, Table 8). In case of chlorophyll under highest fluoride concentration become decreased (Table 7) because in stressed condition the activity of chlorophyll degrading enzyme chlorophyllase become increased (Normen et al., 2009) beside these fluoride also induced reduction in Fe^{2+},which is essential for chlorophyll biosynthesis (Ellumni et al., 2013).

TABLE 7
IMPACT OF CHEMICAL FERTILIZER AND FLUORIDE ON BIOCHEMICAL ATTRIBUTES OF FLAG LEAVES OF PADDY

Treatments (mg Kg^{-1} F)	$Chlorophyll_a$ (mg g^{-1} FW)	$Chlorophyll_b$ (mg g^{-1} FW)	Total Chlorophyll (mg g^{-1} FW)	Total Soluble Sugar(mg g^{-1} FW)	Proline (µg g^{-1} FW)
Control(T_5)	1.924^a 1.709^a 1.489^a	1.007^a 0.905^a 0.790^a	2.877^a 2.870^a 2.507^a	25.33^b 34.33^a 33.33^a	4.146^a 2.745^a 106.9^a
T_1	1.784^{ab} 1.690^a 1.388^{ab}	0.936^a 0.780^{ab} 0.755^{ab}	2.689^a 2.626^{ab} 2.359^{ab}	25.44^b 37.67^a 34.00^a	4.6235^a 3.134^a 118.0^a
T_2	1.485^{abc} 1.645^{ab} 1.302^{ab}	0.812^a 0.721^{ab} 0.625^{ab}	2.611^a 2.435^{abc} 2.095^{ab}	33.67^b 38.67^a 36.00^a	6.358^a 3.267^a 128.4^a
T_3	1.428^{abc} 1.542^{ab} 1.231^{ab}	0.779^a 0.718^{ab} 0.616^{ab}	2.491^a 2.392^{abc} 2.012^{ab}	41.00^b 40.00^a 38.00^a	6.648^a 4.356^a 172.5^a
T_4	1.378^{abc} 1.314^{abc} 1.001^{ab}	0.773^a 0.611^{ab} 0.477^{ab}	2.443^a 2.072^{abc} 1.599^{ab}	41.67^b 40.33^a 45.33^a	6.693^a 4.578^a 282.1^a
T_6	1.355^{abc} 1.129^{bc} 0.914^{ab}	0.757^a 0.514^{ab} 0.431^{ab}	2.411^a 1.768^{bc} 1.453^{ab}	44^b 42.67^a 64.00^a	7.248^a 4.878^a 300.4^a
T_7	1.184^{bc} 1.004^c 0.868^{ab}	0.668^a 0.463^b 0.410^{ab}	2.217^a 1.573^c 1.384^{ab}	47^b 46.33^a 89.00^a	7.504^a 5.156^a 339.4^a
T_8	1.056^c 0.957^c 0.596^b	0.552^a 0.460^b 0.293^b	1.888^a 1.517^c 0.964^b	67.67^a 51.33^a 112.00^a	8.549^a 6.345^a 359.1^a
SEM(±)	0.112 0.093 0.139	0.110 0.058 0.081	0.253 0.168 0.243	3.802 2.959 19.849	1.061 0.744 60.048
LSD at 5%	0.587 0.489 0.729	0.577 0.303 0.427	1.330 0.881 1.276	19.97 15.54 104.3	5.576 3.908 315.5
CV (%)	23.1 20.3 37.9	41.9 26.8 44.3	31.0 23.3 40.5	28 21.4 105.5	49.2 51.8 79.8

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

Upper, middle and lower value indicates data of 30 DAT, 45 DAT and 60 DAT, DAT days after transplanting , SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance

Total soluble sugar and proline accumulation were less in amount in the leaves of paddy which were grown under vermicompost, compost, bacterial consortia and different concentration of sodium fluoride treated plots as compared to the plots which were treated with chemical fertilizers and different strength of fluoride. In both of these treatments, highest value was noted with T_8 (500mg Kg^{-1} fluoride) and lowest value was recorded with T_1 (organic inputs treated plots, Table 7 and Table 8) and control. The results related to stress indicators i.e., total soluble sugar and proline clearly indicate that due to higher concentration of sodium fluoride treatment (500 mg Kg^{-1}fluoride, Table 7 and Table 8) highest level of sugar and proline accumulated in the flag leaf (Datta et al., 2012). This might have contributed towards increase in the level of sugar and proline content for enhancing the tolerance capacity of plant under stress condition (Yang and Miller, 1963).

TABLE 8
IMPACT OF VERMICOMPOST, COMPOST, BACTERIAL CONSORTIUM AND FLUORIDE ON BIOCHEMICAL ATTRIBUTES OF FLAG LEAVES OF PADDY

Treatments (mg Kg^{-1} F)	$Chlorophyll_a$ (mg g^{-1} FW)	$Chlorophyll_b$ (mg g^{-1} FW)	Total Chlorophyll (mg g^{-1} FW)	Total Soluble Sugar(mg g^{-1} FW)	Proline (µg g^{-1} FW)
Control(T_5)	1.449^{a} 1.100^{a} 0.966^{b}	0.812^{ab} 0.519^{ab} 0.401^{a}	2.551^{a} 1.753^{a} 1.460^{a}	21.33^{a} 3.10^{a} 48.33^{a}	3.001^{a} 11.27^{bc} 8.07^{c}
T_1	1.905^{a} 1.589^{a} 3.356^{a}	1.800^{a} 0.814^{a} 0.641^{a}	3.323^{a} 2.627^{a} 2.174^{a}	22.00^{a} 7.67^{a} 50.67^{a}	3.758^{a} 17.45^{a} 10.88^{c}
T_2	1.861^{a} 1.552^{a} 1.332^{b}	1.089^{ab} 0.799^{ab} 0.633^{a}	3.183^{a} 2.568^{a} 2.131^{a}	25.00^{a} 13.00^{a} 51.00^{a}	4.080^{a} 14.02^{ab} 17.71^{abc}
T_3	1.706^{a} 1.449^{a} 1.307^{ab}	1.027^{ab} 0.724^{ab} 0.559^{a}	2.864^{a} 2.360^{a} 2.019^{a}	31.67^{a} 14.67^{a} 54.00^{a}	4.269^{a} 12.41^{bc} 17.77^{bc}
T_4	1.650^{a} 1.125^{a} 1.207^{b}	0.848^{ab} 0.520^{ab} 0.522^{a}	2.722^{a} 1.803^{a} 1.853^{a}	32.33^{a} 16.00^{a} 55.00^{a}	4.647^{a} 11.66^{bc} 23.99^{abc}
T_6	1.372^{a} 0.978^{a} 0.953^{b}	0.792^{ab} 0.478^{ab} 0.390^{a}	2.384^{a} 1.574^{a} 1.428^{a}	35.67^{a} 16.67^{a} 60.67^{a}	5.080^{a} 10.60^{bc} 30.31^{abc}
T_7	1.346^{a} 0.934^{a} 0.889^{b}	0.612^{b} 0.451^{ab} 0.387^{a}	2.274^{a} 1.497^{a} 1.360^{a}	44.67^{a} 22.30^{a} 63.00^{a}	6.192^{a} 10.49^{bc} 44.20^{ab}
T_8	1.024^{a} 0.862^{a} 0.877^{b}	0.607^{b} 0.413^{b} 0.379^{a}	2.134^{a} 1.381^{a} 1.357^{a}	49.67^{a} 36.33^{a} 67.67^{a}	6.570^{a} 9.31^{c} 49.99^{a}
SEM(±)	0.210 0.127 0.375	0.174 0.067 0.091	0.313 0.212 0.287	8.198 5.956 10.016	0.784 0.771 5.576
LSD at 5%	1.104 0.670 1.969	0.911 0.349 0.477	1.646 1.116 1.506	43.07 31.29 52.62	4.169 4.052 29.29
CV (%)	40.9 31.9 82.6	54.9 33.8 55.7	35.1 32.8 49.9	75 110.2 53.4	50.7 19 65.9

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

Upper, middle and lower value indicates data of 30 DAT, 45 DAT and 60 DAT, DAT days after transplanting , SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance

3.3 Photosynthetic rate

Photosynthetic rate of paddy grown under vermicompost, compost, bacterial consortia and different concentration of sodium fluoride treated plots were recorded highest with T_1 treatment (25 mg Kg^{-1} fluoride). The value is above the value of control set (Raja et al., 2006; Zeats et al., 2010; Rajasekar and Elango, 2011; Khan and Ishaq, 2011; Sharma et al., 2014). Lowest value were recorded with T_8 (500mg Kg^{-1} fluoride).Paddy which were grown under chemical fertilizers (recommended dose) and different concentration of sodium fluoride highest value of above mentioned parameter were recorded with T_5 (Control) and lowest value were recorded with T_8 (500mg Kg^{-1} fluoride) (Table 9).

TABLE 9
COMPARATIVE STUDY BETWEEN TWO DIFFERENT TREATMENT COMBINATIONS ON PHOTOSYNTHETIC RATE OF FLAG LEAVES OF PADDY

Treatments (mg Kg^{-1} F)	Photosynthetic rate (μ mol^{-1} cm^{2-1} sec, Chem+Fluoride)	Photosynthetic rate (μ mol^{-1} cm^{2-1} sec, VC+Comp+BC+Fluoride)
Control (T_5)	9.823^{a} 19.30^{a} 23.95^{a}	9.267^{d} 11.27^{bc} 11.51^{bc}
T_1	8.923^{ab} 17.47^{ab} 14.53^{b}	13.033^{a} 17.45^{a} 17.50^{a}
T_2	8.487^{bc} 14.03^{bc} 13.23^{b}	11.900^{b} 14.02^{ab} 13.50^{b}
T_3	7.773^{cd} 11.55^{cd} 11.52^{b}	10.573^{c} 12.41^{bc} 12.63^{b}
T_4	7.140^{de} 10.68^{cd} 11.07^{b}	9.563^{cd} 11.66^{bc} 12.00^{bc}
T_6	6.783^{de} 9.64^{d} 10.59^{b}	8.863^{de} 10.60^{bc} 11.34^{bc}
T_7	6.223^{e} 9.26^{d} 10.10^{b}	8.063^{ef} 10.49^{bc} 10.18^{cd}
T_8	4.957^{f} 8.47^{d} 8.37^{b}	7.740^{f} 9.31^{c} 8.49^{d}
SEM(±)	0.201 0.764 1.567	0.204 0.771 0.418
LSD at 5%	1.054 4.013 8.230	1.071 4.052 2.198
CV (%)	8.0 18.3 36.4	6.2 19 10.3

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

Upper, middle and lower value indicates data of 30 DAT, 45 DAT and 60 DAT, DAT days after transplanting , SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

3.4 Yield attributes

Length and weight of panicles, number of grains ,number of filled and chaffy grains,1000 seed weight, seed weight and straw weight, Number of tillers of paddy grown under indigenous organic resources treated plots were again recorded highest with T_1 (25mg/Kg F) . In case of tiller production are highly responsible to available phosphorous level in soil which was maximum again in T_1 (25 mg/Kg F) (Alam et al., 2009). Lowest value of above mentioned parameters were recorded with T_8 (500 mg/Kg F). Because in the present investigation macromolecular level change took place within plant due to inoculation of bacterial consortia under field condition (Maitra et al., 2013) as well as in the present investigation some mineral element may acted as an activator for accelerating the enzymatic activity and with lowest concentration of fluoride i.e., 25 mg Kg^{-1}fluoride such type of action might have occurred due to which high yield with low fluoride concentration took place (Ram et al., 2007) (Table 10, Table 11 and Table 12) (Figure 2).

TABLE 10
COMPARATIVE STUDY BETWEEN TWO DIFFERENT TREATMENT COMBINATIONS ON YIELD ATTRIBUTES OF PADDY

Treatments (mg Kg^{-1} F)	Number of tiller (Chem+Fluoride)	Number of tiller (VC+Comp+BC+ Fluoride)	Length of panicles (cm, Chem+ Fluoride)	Length of panicles (cm,VC+Comp+BC+ Fluoride)	Weight of panicles (g, Chem+Fluoride)	Weight of Panicles (g,VC+Comp+BC+ Fluoride)
Control (T_5)	16.00^{a} 17.87^{a} 14.67^{a}	8.33^{bc} 14.67^{a} 13.00^{ab}	24.05^{a}	22.42^{cde}	48.48^{a}	40.17^{b}
T_1	14.19^{ab} 16.17^{a} 13.17^{a}	18.92^{a} 18.83^{a} 19.00^{a}	23.47^{a}	24.36^{a}	45.95^{ab}	46.30^{a}
T_2	13.25^{abc} 15.83^{a} 13.00^{a}	15.42^{ab} 18.50^{a} 18.33^{a}	23.30^{a}	23.22^{b}	45.92^{ab}	42.47^{b}
T_3	11.67^{abcd} 15.33^{a} 12.67^{a}	13.58^{abc} 16.50^{a} 16.33^{ab}	22.92^{a}	23.01^{bc}	45.72^{ab}	41.83^{b}
T_4	10.17^{bcd} 13.92^{a} 12.33^{a}	13.31^{abc} 15.00^{a} 16.00^{ab}	22.52^{a}	22.69^{bcd}	42.89^{ab}	40.91^{b}
T_6	8.67^{cd} 13.50^{a} 11.33^{a}	7.00^{bc} 14.67^{a} 12.50^{ab}	22.46^{a}	22.30^{de}	42.71^{ab}	36.81^{c}
T_7	8.00^{d} 10.00^{ab} 10.83^{a}	6.00^{c} 14.33^{a} 11.33^{b}	22.09^{a}	22.03^{de}	41.66^{ab}	36.06^{c}
T_8	7.00^{d} 5.33^{b} 10.00^{a}	5.33^{c} 13.00^{a} 10.67^{b}	22.01^{a}	21.87^{e}	39.62^{b}	34.93^{c}
SEM(±)	0.895 1.472 0.852	1.554 1.187 1.171	0.508	0.304	1.328	0.480
LSD at 5%	4.701 7.734 4.475	8.164 6.237 6.152	2.671	0.651	6.975	2.523
CV (%)	24 32.7 20.9	42.4 22.7 24	6.7	1.6	9.0	3.6

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

Upper, middle and lower value indicates data of 30 DAT, 45 DAT and 60 DAT, DAT days after transplanting , SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

TABLE 11
IMPACT OF CHEMICAL FERTILIZER AND FLUORIDE ON YIELD ATTRIBUTES OF PADDY

Treatments (mg Kg^{-1} F)	Grains number	Number of filled grains	Number of chaffy grains	1000 seed weight(g)	Seed weight (Kg ha^{-1})	Straw weight (Kg ha^{-1})
Control(T_5)	166.5^{a}	129.7^{a}	50.87^{a}	15.32^{a}	6500^{a}	8500^{a}
T_1	164.3^{a}	127.8^{a}	47.78^{a}	15.15^{ab}	6350^{a}	7267^{ab}
T_2	162.4^{a}	124.5^{a}	41.27^{a}	15.12^{abc}	6183^{a}	7183^{ab}
T_3	154.3^{a}	121.1^{a}	39.70^{a}	14.89^{bcd}	5650^{a}	6900^{ab}
T_4	151.8^{a}	117.1^{a}	36.87^{a}	14.83^{cd}	4933^{a}	6667^{ab}
T_6	147.9^{a}	108.2^{a}	36.87^{a}	14.77^{d}	4883^{a}	5267^{b}
T_7	146.3^{a}	103.4^{a}	36.50^{a}	14.71^{d}	4817^{a}	5100^{b}
T_8	130.1^{a}	101.0^{a}	34.67^{a}	14.63^{d}	4617^{a}	4883^{b}
SEM(±)	11.06	10.862	3.108	0.084	364.775	547.342
LSD at 5%	58.35	56.12	16.33	0.280	1916.4	2875.5
CV(%)	21.8	27.5	23.0	0.8	19.9	25.4

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

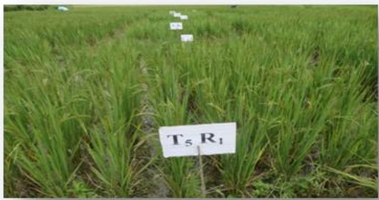
SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance

TABLE 12
IMPACT OF VERMICOMPOST, COMPOST, BACTERIAL CONSORTIUM AND FLUORIDE ON YIELD ATTRIBUTES OF PADDY

Treatments (mg Kg^{-1} F)	Grains number	Number of filled grains	Number of chaffy grains	1000 seed weight(g)	Seed weight (Kg ha^{-1})	Straw weight (Kg ha^{-1})
Control(T_5)	141.9^{a}	109.8^{d}	37.35^{a}	15.84^{cd}	5150^{ab}	5017^{b}
T_1	177.3^{a}	161.2^{a}	16.10^{b}	16.35^{a}	6183^{a}	7417^{a}
T_2	165.5^{ab}	139.6^{b}	25.90^{ab}	16.27^{ab}	5717^{a}	7283^{a}
T_3	162.9^{ab}	130.5^{bc}	32.40^{ab}	16.14^{b}	5600^{ab}	6333^{ab}
T_4	156.1^{bc}	123.2^{cd}	32.90^{ab}	15.98^{cd}	5450^{ab}	5983^{ab}
T_6	140.9^{c}	109.8^{d}	31.20^{ab}	15.73^{de}	4500^{b}	4983^{b}
T_7	135.4^{c}	108.7^{d}	26.80^{ab}	15.59^{ef}	4433^{b}	4933^{b}
T_8	104.3^{d}	87.9^{e}	16.35^{b}	15.50^{f}	2283^{c}	4783^{b}
SEM(±)	5.97	14.20	4.67	0.044	210.115	319.823
LSD at 5%	19.97	14.03	15.61	0.146	1103.9	1680.2
CV (%)	5.7	4.9	24.1	0.4	12.8	16.4

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance



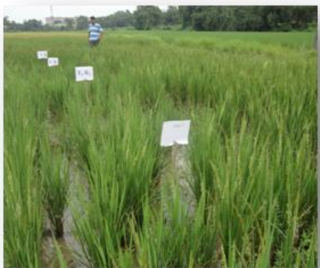
(a)

30 DAT(T_8 , 500 mg Kg^{-1} fluoride)

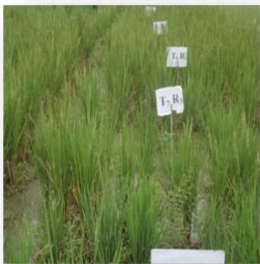
30 DAT (T_7, 400 mg Kg^{-1} fluoride)

Indigenous Organic inputs

Indigenous organic inputs



60 DAT (T_8, 500 mg Kg^{-1} fluoride)
(c)



45 DAT (T_7, 400 mg Kg^{-1} fluoride)
(b)

FIGURE 2: SHOWS THE IMPACT OF INDIGENOUS ORGANIC INPUTS ON PADDY UNDER HIGHEST CONCENTRATION FLUORIDE TREATED PLOTS

3.5 Fluoride accumulation in different plant parts

The quantitative estimation demonstrated that highest amount of fluoride accumulated in the root and lesser amount of fluoride was accumulated in the seed under both of the treatment combinations. Here also maximum amount of fluoride accumulated under chemical fertilizers and different concentrations of sodium fluoride treatment (Table 13). The combating potentiality of bacterial consortia was very clear from the data of level of fluoride within the plant parts. They can capable to reduce the fluoride level in the different parts of paddy. Because Paddy has fibrous roots which float on the superficial layer of soil, therefore, it took meagre amount in their body and accordingly due to passive transport not much of fluoride entered into the plant system.The variations among treatments were clear from CV (%) value as well as differences among data were also pronounced with DMRT wordings. Among all the treatments some of them showed the differences among themselves and some of them were statistically at par.

TABLE 13
COMPARATIVE STUDY BETWEEN TWO DIFFERENT TREATMENT COMBINATIONS ON FLUORIDE ACCUMULATION OF DIFFERENT PARTS OF PADDY

Treatments (mg Kg^{-1} F)	Root (ppm, Chem+ Fluoride)	Root (ppm, VC+Comp +BC+Fluoride)	Shoot (ppm ,Chem+ Fluoride)	Shoot (ppm, VC+Comp +BC+Fluoride)	Leaf (ppm,Chem+ Fluoride)	Leaf (ppm VC+Comp+ BC+Fluoride,)	Grains (ppm,Chem +Fluoride)	Grains (ppm, VC+Comp+ BC+Fluoride,)
Control (T_5)	0.012^{g}	0.000^{f}	0.003^{f}	0.000^{e}	0.002^{de}	0.000^{d}	0.000^{e}	0.000^{e}
T_1	0.295^{f}	0.150^{e}	0.015^{e}	0.007^{de}	0.008^{cd}	0.006^{cd}	0.005^{de}	0.000^{e}
T_2	0.485^{e}	0.235^{d}	0.018^{de}	0.010^{de}	0.014^{bc}	0.007^{cd}	0.008^{cde}	0.000^{e}
T_3	0.635^{d}	0.270^{d}	0.024^{cd}	0.014^{cd}	0.016^{b}	0.012^{bcd}	0.012^{cd}	0.004^{d}
T_4	0.660^{cd}	0.335^{c}	0.026^{bcd}	0.017^{bcd}	0.019^{b}	0.018^{abc}	0.017^{bc}	0.007^{c}
T_6	0.735^{bc}	0.345^{c}	0.031^{bc}	0.022^{abc}	0.026^{a}	0.020^{abc}	0.023^{ab}	0.010^{b}
T_7	0.755^{b}	0.465^{b}	0.034^{ab}	0.026^{ab}	0.030^{a}	0.025^{ab}	0.029^{a}	0.012^{b}
T_8	0.905^{a}	0.550^{a}	0.040^{a}	0.030^{a}	0.033^{a}	0.030^{a}	0.033^{a}	0.016^{a}
SEM(±)	0.027	0.016	0.002	0.003	0.003	0.004	0.003	0.001
LSD at 5%	0.091	0.029	0.008	0.010	0.007	0.014	0.011	0.002
CV (%)	6.9	7.8	14.4	28.1	15.8	39.7	27.3	16.4

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

3.6 Soil physical and physico-chemical parameters

Results also showed that both chemical fertilizer and sodium fluoride (different concentration) have no influence on soil physical and physico-chemical parameters (Table 14 to Table 19). Except organic matter (%) and number of bacterial and fungal colonies (Table 17). They possess inversely proportionate relationship i.e., increment of accumulation of organic matter, number of bacterial and fungal colonies were decreased (Rao and Pal, 1978).

Micronutrients were also increased because here also single super phosphate acted as a major source of micronutrients. The data shows differences among themselves from the DMRT wording. On the other hand the number of bacterial colony, in T_1 and T_2 are statistically at par. In case of fungal colony, T_6, T_7 and T_8 are statistically at par. In case of zinc T_1, T_7 and T_8 , for manganese T_7 and T_8, and for cupper T_7 and T_8 are statistically at par(Table 19).

Vermicompost, compost, bacterial consortia and fluoride treatment combination showed significant impact on soil physical and physico-chemical, microbiological properties (Table 14 to Table 19) (Suhane, 2007; Weber et al., 2007; Azarmi et al., 2008; Jadia and Fulekar, 2008; Sinha and Heart, 2012) . During the field experiment with paddy, soil physical parameters *viz.* moisture content (%), particle density, porosity (%) highest value was recorded with T_1 (25mg Kg^{-1} fluoride).The value is above the value of control set. Lowest value was recorded with T_8 (500 mg Kg^{-1}fluoride, Table 14). Except bulk density, here reverse condition was also found i.e., highest value was recorded with T_8 (500mg Kg^{-1}fluoride) and lowest value was recorded with T_1 (25 mg Kg^{-1}fluoride). Among the physical parameters especially bulk density, particle density and porosity (%) are true indicator of soil proper physical condition. Due to inputs of organic matter (vermicompost, compost and bacterial consortium) in soil, volume gradually increased (D =M/V) then density decreased such as bulk density but porosity

increased (Table 14).Lower bulk density indicates the favourable soil physical condition. Due to organic matter inputs particle density increased (Table 14). From the DMRT wordings of first part of the field experiment it is clear that for moisture content, T_4 and T_5, for bulk density, T_2, T_3 ,T_4 and T_5; T_6 and T_7,for particle density T_3 and T_4; T_6 and T_7, for porosity(%) T_2 and T_3; T_4 and T_5 are statistically at par (Table 14).

TABLE 14
COMPARATIVE STUDY BETWEEN TWO TREATMENT COMBINATION ON SOIL PHYSICAL PARAMETERS (POST HARVESTED)

Treatments (mg Kg^{-1} F)	Moisture content(%, Chem+ Fluoride)	Moisture content(%,VC+ Comp+BC++ Fluoride)	Bulk density (g cc^{-1}, Chem+Fluoride)	Bulk density (g cc^{-1}, VC+Comp+BC++ Fluoride)	Particle density (g cc^{-1},Chem+Fluoride)	Particle density(g cc^{-1}, VC+Comp+BC++ Fluoride)	Porosity (%, Chem+Fluoride)	Porosity (%, VC+Comp+BC+ Fluoride)
Control (T_5)	14.61^{b}	14.34^{c}	0.546^{f}	0.609^{c}	2.250^{bc}	2.171^{cd}	70.96^{c}	72.15^{c}
T_1	14.25^{d}	80.05^{a}	0.637^{c}	0.561^{d}	3.931^{a}	2.360^{a}	81.61^{a}	75.01^{a}
T_2	11.76^{e}	17.16^{b}	0.638^{c}	0.596^{c}	2.135^{d}	2.210^{b}	71.46^{c}	73.23^{b}
T_3	15.09^{a}	14.58^{c}	0.642^{b}	0.603^{c}	2.040^{e}	2.185^{c}	68.60^{d}	72.88^{b}
T_4	10.98^{f}	14.37^{c}	0.608^{d}	0.606^{c}	2.210^{c}	2.178^{c}	71.15^{c}	72.29^{c}
T_6	14.36^{c}	13.91^{cd}	0.656^{a}	0.630^{b}	2.044^{e}	2.160^{de}	70.00^{cd}	71.11^{d}
T_7	10.23^{g}	12.39^{de}	0.597^{e}	0.635^{b}	2.274^{b}	2.157^{de}	75.01^{b}	70.41^{e}
T_8	10.97^{f}	12.04^{e}	0.598^{e}	0.649^{a}	2.130^{d}	2.147^{e}	71.16^{c}	69.66^{f}
SEM(±)	0.009	0.520	0.001	0.004	0.016	0.005	0.601	0.143
LSD at 5%	0.028	1.740	0.003	0.012	0.054	0.017	2.008	0.477
CV (%)	0.1	3.3	0.2	0.9	1.0	0.3	1.2	0.3

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

Micronutrients and number of microorganisms were also increased in case of paddy under such treatment combinations (Table 17 and Table 19) (Sharma et al., 2001; Garai et al., 2013,Jordao et al., 2006; Manyuchi et al., 2013;Sinha and Heart, 2012).

Vermicompost, compost, bacterial consortia and fluoride (different concentration) did not show any remarkable influence on soil physico-chemical parameters *viz.*pH and EC (Table 15).

TABLE 15
COMPARATIVE STUDY BETWEEN TWO TREATMENT COMBINATION ON SOIL PHYSICO-CHEMICAL PARAMETERS (POST HARVESTED)

Treatments (mg Kg^{-1} F)	pH (Chem+Fluoride)	pH (VC+Comp+BC+ Fluoride)	EC (ms cm^{-1}, Chem+Fluoride)	EC (ms cm^{-1}, VC+Comp+BC++ Fluoride)
Control(T_5)	6.46^{a}	6.17^{bc}	0.050^{c}	0.080^{ab}
T_1	6.46^{a}	6.48^{a}	0.080^{b}	0.055^{ab}
T_2	6.20^{c}	6.22^{b}	0.075^{b}	0.040^{b}
T_3	6.13^{d}	6.13^{c}	0.085^{b}	0.050^{ab}
T_4	6.06^{e}	5.98^{d}	0.055^{c}	0.050^{ab}
T_6	5.77^{f}	5.72^{e}	0.085^{b}	0.060^{ab}
T_7	5.68^{f}	5.74^{e}	0.075^{b}	0.046^{b}
T_8	6.30^{b}	6.48^{a}	0.185^{a}	0.130^{a}
SEM(±)	0.008	0.014	0.005	0.023
LSD at 5%	0.011	0.048	0.015	0.076
CV (%)	0.2	0.3	7.6	50.3

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

Available nitrogen, phosphorous, potassium highest value was recorded with T_1 (25mg Kg^{-1}fluoride) and lowest value was recorded with T_8 (500 mg Kg^{-1}fluoride, Table 16). NPK are essential nutrients for crop species. Among all of them phosphorous and potassium makes plant drought resistant. In the present experiment the trend of the results revealed that organic indigenous inputs have some beneficial impacts on soil health (Garai et al., 2013). Above mentioned nutrients were present in such concentration that is beneficial for plant growth. .From the data sheet it is found that available nitrogen content was low (<272 Kg/ha,), available phosphorous was high (>90 Kg/ha) and available potassium was medium (136-337.5 Kg/ha) in soil.

TABLE 16
COMPARATIVE STUDY BETWEEN TWO DIFFERENT TREATMENT SOIL PHYSICO-CHEMICAL PARAMETERS (POST HARVESTED)

Treatments (mg Kg^{-1} F)	Available Nitrogen (Kg ha^{-1}, Chem+ Fluoride)	Available Nitrogen (Kg ha^{-1}, VC+Comp+BC+Fluoride)	Available Phosphorous (Kg ha^{-1}, Chem+ Fluoride)	Available Phosphorous (Kg ha^{-1},VC+Comp+BC+Fluoride)	Available Potassium(Kgha^{-1}, Chem+Fluoride)	Available Potassium (Kg ha^{-1} ,VC+Comp+BC+Fluoride)
Control (T_5)	116.5^{b}	125.5^{d}	500.3^{cde}	185.4^{cd}	186.3^{a}	519.1^{c}
T_1	116.5^{b}	143.8^{a}	537.0^{bcd}	229^{a}	153.3^{de}	641.3^{a}
T_2	130.0^{a}	134.7^{b}	548.9^{bc}	204.2^{b}	155.6^{d}	552.0^{b}
T_3	130.5^{a}	130.1^{c}	449.9^{ef}	194.1^{bc}	136.8^{g}	548.9^{b}
T_4	107.6^{c}	129.9^{c}	480.1^{def}	191.3^{c}	152.7^{e}	522.6^{c}
T_6	107.5^{c}	121.0^{e}	419.2^{f}	176.0^{d}	176.9^{b}	477.6^{d}
T_7	129.9^{a}	120.1^{f}	585.3^{ab}	154.3^{e}	143.1^{f}	474.2^{d}
T_8	116.0^{b}	117.2^{g}	643.5^{a}	102.2^{f}	160.1^{c}	460.6^{d}
SEM(±)	0.287	0.166	18.22	3.51	0.745	6.94
LSD at 5%	0.958	0.554	60.93	11.73	2.492	23.22
CV (%)	0.3	0.2	5.0	2.8	0.7	1.9

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

Organic matter essential for microorganism's growth and activity. Number of bacterial and fungal colony possesses inversely proportionate relationship with organic matter. Under these field experiments with paddy highest number of microorganisms were found under T_1 and least number of microorganisms were found under T_8 (Table 17). Fluoride has detrimental effect on microbial population as a result; more organic matter was accumulated on surface soil due to hindrance of fluoride toxicity on growth and activity of microorganisms. Such types of organic inputs were beneficial for microorganisms which can help them to keep their activity under such stressed condition (Jadia and Fulekar, 2008).

TABLE 17
COMPARATIVE STUDY BETWEEN TWO DIFFERENT TREATMENT COMBINATIONS ON SOIL ORGANIC MATTER, NUMBER OF BACTERIAL COLONY AND NUMBER OF FUNGAL COLONY (POST HARVESTED)

Treatments (mg Kg^{-1} F)	Organic matter (%,Chem+Fluoride)	Organic matter (%,VC+Comp+BC+Fluoride)	Number of bacterial colony (Chem+ Fluoride)	Number of bacterial colony(VC+Comp+BC+Fluoride)	Number of fungal colony(Chem+ Fluoride)	Number of fungal colony (VC+Comp+BC+Fluoride)
Control (T_5)	0.654^{h}	0.680^{d}	47^{a}	32.00^{d}	31.50^{a}	16.50^{d}
T_1	0.661^{g}	0.012^{h}	38.50^{b}	68.50^{a}	29.00^{a}	72^{a}
T_2	2.190^{f}	0.028^{g}	36.00^{b}	48.50^{b}	19.00^{b}	38^{b}
T_3	2.221^{e}	0.278^{f}	34.00^{bc}	45.50^{b}	16.50^{bc}	28^{c}
T_4	2.359^{d}	0.493^{e}	31.00^{c}	37.50^{c}	14.50^{cd}	17.50^{d}
T_6	2.591^{c}	2.021^{c}	22.00^{d}	30.00^{de}	11.50^{d}	14.50^{d}
T_7	2.692^{b}	2.224^{b}	12.50^{e}	26.50^{e}	10.50^{d}	13.00^{d}
T_8	2.864^{a}	2.362^{a}	7.50^{f}	21.00^{f}	10.50^{d}	11.00^{d}
SEM(±)	0.002	0.004	1.438	1.499	1.217	2.645
LSD at 5%	0.006	0.015	4.808	5.011	4.071	8.845
CV (%)	0.1	0.6	7.1	5.5	9.6	14.2

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

From the Table 18, it is clear that highest amount of calcium and magnesium was present on T_1 (25mg Kg^{-1} fluoride) and lowest amount was present in T_8 (500 mg Kg^{-1} fluoride) .Vermicompost acts as a major source of calcium and magnesium (Suhane, 2007; Jadia and Fulekar, 2008). The field experiment with paddy, available calcium was >0.5 (T_1) i.e., medium and magnesium content was >0.2 (T_1) i.e., medium but good for plant .Fluoride binds or forms complexes with calcium and magnesium and inhibits the transport of fluoride into plants (Takmaz-Nisancioglu and Davison, 1988; Dey et al., 2012). Therefore, bioaccumulation of fluoride in plant parts decreased in the presence of calcium and magnesium in soil.

TABLE 18
COMPARATIVE STUDY BETWEEN TWO DIFFERENT TREATMENT COMBINATIONS ON AVAILABLE CALCIUM AND MAGNESIUM (POST HARVESTED)

Treatments (mg Kg^{-1} F)	Available Calcium (meq 100 g^{-1}, Chem+Fluoride)	Available Calcium (meq 100 g^{-1}, VC+Comp+ BC+Fluoride)	Available magnesium (meq 100 g^{-1}, Chem+Fluoride)	Available magnesium (meq 100 g-1, VC+Comp+ BC+Fluoride)
Control(T_5)	0.595^{a}	0.450^{e}	0.470^{ab}	0.450^{e}
T_1	0.495^{a}	0.570^{a}	0.360^{bc}	0.570^{a}
T_2	0.605^{a}	0.555^{b}	0.380^{b}	0.555^{b}
T_3	0.565^{a}	0.525^{c}	0.260^{cd}	0.525^{c}
T_4	0.545^{a}	0.495^{d}	0.240^{d}	0.495^{d}
T_6	0.520^{a}	0.415^{f}	0.225^{d}	0.415^{f}
T_7	0.525^{a}	0.390^{g}	0.560^{a}	0.390^{g}
T_8	0.570^{a}	0.380^{g}	0.390^{b}	0.380^{g}
SEM(±)	0.044	0.004	0.032	0.011
LSD at 5%	0.146	0.011	0.107	0.038
CV(%)	11.2	1.1	12.5	5.5

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

Table 19 represents the impact of vermicompost, compost, bacterial consortium and fluoride on soil micronutrients. An organic input (especially vermicompost) acts as a major source of soil micronutrients (Kale et al., 1992, Jordao et al., 2006; Garai et al., 2013; Manyuchi et al., 2013). Therefore, such type of treatment combinations can helpful to increase all the micronutrients but manganese and iron content in soil were greatly influenced by such treatment combinations (Zinc->0.86, Manganese->1.0, Cupper- >0.2 and iron- >4.00). But they have no significant effect on soil micronutrients.

TABLE 19
COMPARATIVE STUDY BETWEEN TWO DIFFERENT TREATMENT COMBINATIONS ON SOIL MICRONUTRIENTS (POST HARVESTED)

Treatments (mg Kg^{-1} F)	Available zinc (ppm, Chem+ Fluoride)	Available zinc (ppm, VC+Comp+BC +Fluoride)	Available manganese (ppm ,Chem+ Fluoride)	Available manganese (ppm, VC+Comp+BC+Fl uoride)	Available cupper (ppm,Chem+ Fluoride)	Available cupper (ppm VC+Comp+BC +Fluoride,)	Available iron (ppm,Chem+ Fluoride)	Available iron (ppm, VC+Comp+ BC+Fluorid e,)
Control (T_5)	1.180^{c}	1.490^{b}	12.69^{c}	12.34^{g}	3.145^{d}	3.790^{c}	25.01^{e}	26.08^{b}
T_1	0.710^{d}	0.730^{de}	12.38^{d}	9.13^{h}	2.285^{e}	4.055^{b}	22.70^{f}	25.05^{e}
T_2	0.610^{e}	1.240^{c}	4.93^{g}	12.61^{f}	1.780^{f}	3.380^{e}	24.95^{e}	25.13^{de}
T_3	1.390^{a}	0.680^{e}	10.20^{f}	12.88^{e}	3.510^{b}	3.610^{d}	25.65^{b}	26.05^{b}
T_4	0.720^{d}	0.760^{d}	11.71^{e}	16.59^{b}	3.610^{a}	3.755^{c}	25.31^{d}	24.56^{f}
T_6	1.380^{a}	1.470^{b}	14.72^{b}	14.12^{d}	3.360^{c}	4.180^{a}	25.95^{a}	26.33^{a}
T_7	1.310^{b}	1.815^{a}	16.93^{a}	17.20^{a}	3.480^{b}	3.810^{c}	25.33^{cd}	25.27^{c}
T_8	1.335^{b}	1.190^{c}	16.86^{a}	16.15^{c}	3.520^{b}	3.305^{e}	25.39^{c}	25.22^{cd}
SEM(±)	1.7	0.020	0.023	0.015	0.014	0.026	0.020	0.031
LSD at 5%	0.044	0.065	0.075	0.049	0.048	0.086	0.068	0.103
CV (%)	0.013	2.4	0.3	0.2	0.7	1.0	0.1	0.2

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

Through comparative study between pre harvested and post harvested soil samples of both of these field experiments, it was clear that organic indigenous inputs can capable of restoring soil health and biodiversity under fluoride stressed condition. Physical parameters especially bulk density reduced in post samples, porosity (%) increased under lower fluoride concentration which indicates favourable physical condition of soil. In order to physico-chemical properties of soil, available nitrogen, phosphorous, potassium, calcium, magnesium and soil micronutrients were increased in post samples with lower fluoride concentration as compared to the pre harvested soil samples(Table 1). In case of soil physico-chemical parameters, the data showed differences among themselves from the DMRT wording which is clear from the tables of both of these field experiments. The CV (%) value indicates that there were variations among treatments. Among all the treatments some of them showed the differences among themselves and these were statistically at par.

3.7 Fluoride accumulation in different layers of soil

In case of paddy grown under organic indigenous treated plots, accumulation of fluoride in surface soil was more than 10cm and 20 cm soil layer especially in T_8 (500 mg Kg^{-1} F) which was above the permissible range (2.57-16.44 mg Kg^{-1}.as recommended by FAO, EPA, and WHO). Lowest accumulation occurred under T_1 (25mg Kg^{-1} F) but here more fluoride accumulated in 20cm soil layer than surface soil which was below the permissible range (2.57-16.44 mg Kg^{-1}.as recommended by FAO, EPA, and WHO) (Table 20). The trends of the results were same in chemical fertilizer and fluoride treated plots. But, amount of fluoride was more in chemical fertilizer treated plots as compared to the vermicompost, compost, bacterial consortia and different concentration of fluoride treated plots. Here, surface soil and 20cm soil layer of T_8 plots accumulated maximum amount of fluoride but only the fluoride content in surface soil was above the permissible range(2.57-16.44 mg Kg^{-1}.as recommended by FAO, EPA, and WHO (Table 20).

TABLE 20
COMPARATIVE STUDY BETWEEN TWO DIFFERENT TREATMENT COMBINATIONS ON FLUORIDE LEVEL IN DIFFERENT LAYERS OF SOIL (POST HARVESTED)

Treatments (mg Kg^{-1} F)	Surface soil (mg Kg^{-1}, Chem+Fluoride)	10cm (mg Kg^{-1},Chem+Fluoride)	20cm (mg Kg^{-1},Chem+Fluoride)	Surface soil (mg Kg^{-1}, VC+Comp+BC+Fluoride)	10cm (mg Kg^{-1}, VC+Comp+BC+Fluoride)	20cm (mg Kg^{-1} VC+Comp+BC+Fluoride)
Control (T_5)	0.01^{g}	0.017^{e}	0.016^{d}	0^{d}	0^{f}	0^{e}
T_1	0.13^{g}	0.745^{d}	0.785^{c}	0.024^{d}	0.455^{e}	0.490^{d}
T_2	0.80^{f}	0.830^{cd}	0.920^{bc}	0.037^{d}	0.550^{de}	0.565^{cd}
T_3	13.42^{e}	0.980^{bcd}	1.015^{bc}	0.044^{d}	0.595^{cd}	0.635^{bc}
T_4	14.16^{d}	1.050^{bc}	1.070^{b}	0.686^{c}	0.640^{bcd}	0.665^{abc}
T_6	25.48^{c}	1.145^{b}	1.165^{b}	0.932^{bc}	0.705^{abc}	0.725^{ab}
T_7	26.07^{b}	1.410^{a}	1.460^{a}	1.126^{b}	0.740^{ab}	0.755^{ab}
T_8	36.46^{a}	1.500^{a}	1.540^{a}	7.122^{a}	0.770^{a}	0.785^{a}
SEM(±)	0.075	0.076	0.072	0.078	0.036	0.035
LSD at 5%	0.250	0.253	0.239	0.111	0.121	0.116
CV (%)	0.7	11.2	10.2	8.9	9.2	8.5

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)
SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

3.8 Air Pollution Tolerance Index (APTI)

Table 21 represents the Air Pollution Tolerance Index values of paddy grown under different treatment combinations viz. different doses of vermicompost, compost, bacterial consortia, recommended doses of chemical fertilizers and different concentration of fluoride and chemical fertilizers plus different concentration of fluoride. In case of paddy, consortia treated plots showed the maximum value but here highest value was recorded with T_8. Therefore, it appeared from the result that such combination of indigenous natural resources became useful even under highest level of fluoride used for such experiment even for field crop like rice i.e., other than tree species.

TABLE 21
AIR POLLUTION TOLERANCE INDEX (APTI) OF PADDY GROWN UNDER TWO DIFFERENT TREATMENT COMBINATIONS VIZ. (A) VERMICOMPOST, COMPOST, BACTERIAL CONSORTIUM AND DIFFERENT CONCENTRATION OF FLUORIDE AND (B) CHEMICAL FERTILIZERS AND DIFFERENT CONCENTRATION OF FLUORIDE

Treatments (mg Kg^{-1} F)	APTI(A)	APTI(B)
Control(T_5)	9.98^a	5.718^b
T_1	10.31^a	5.845^b
T_2	10.31^a	6.833^{ab}
T_3	10.55^a	6.848^{ab}
T_4	11.30^a	7.075^{ab}
T_6	11.60^a	7.250^{ab}
T_7	11.68^a	7.317^{ab}
T_8	12.53^a	8.363^a
SEM(±)	0.583	0.390
LSD at 5%	3.061	2.050
CV (%)	15.8	17

Note: Means followed by the same letter within a treatment were not significantly different at 5% level using Duncan's Multiple Range Test (DMRT)

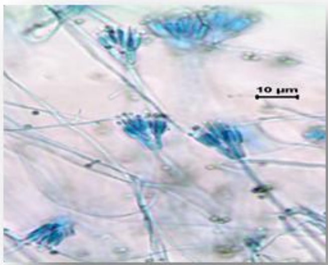
SEM (±) Standard error of mean, LSD at 5% Least Significant of Difference, CV (%) Coefficient of Variance, Chem: Chemical fertilizer, VC: Vermicompost, Comp : Compost , BC: Bacterial Consortium

TABLE 22
NAME OF FUNGAL SPECIES WHICH WAS ISOLATED FROM SOIL OF TREATED PLOTS

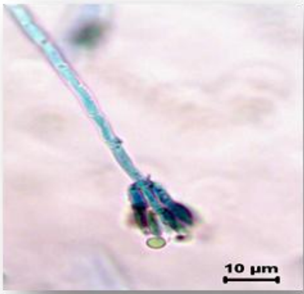
Highest Concentration of Fluoride	Lowest Concentration of Fluoride
Phytopthora sp.	*Penicillium oxalicum*
Penicillium citrimum	*Aspergillus fumigates*
Aspergillus flavus	*Aspergillus flavus*
Botryodiplodia theobromae	
Curvulari lunata	
Fusarium moniliformae	

3.9 Fungal species

Table 22 represents the name of fungal species which were isolated from the soil of treated plots which were treated with different doses of vermicompost, compost, other sources of indigenous inputs i.e., bacterial consortia and different concentration of fluoride and chemical fertilizers(recommended dose) and different doses of fluoride (Figure 3). Species like *Penicillium* , *Aspergillus* and *Fusarium* which were isolated from indigenous organic inputs treated plots and they all are resistant as well as they can survive under fluoride polluted areas (Evdokimova and Korneykova, 2010). Above mentioned fungal species can resist and survive under fluoride stress because they can assimilate fluoride. Among them some are especially *Penicillium* is capable to solubilize insoluble fluoride in vitro (Alharbi et al., 2008). From the above field experiment, the combating efficiency of consortia and other indigenous organic resources clearly revealed that they can reduce the level of fluoride not only in different parts of paddy but also in the soil and simultaneously restore the soil health and biodiversity.



(A)Penicillium citrinum



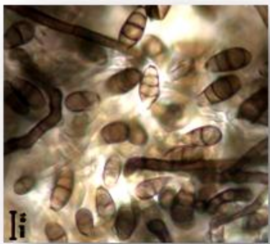
(B) Penicillium oxalicum

***(C) Aspergillus fumigates* Fresenius**

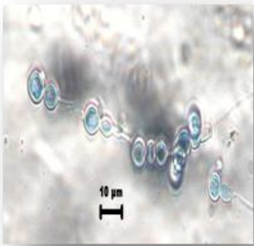
***(D) Aspergillus flavus* Link**

***(E)Phytophthora* de Bary**

(F) Fusarium moniliformae
Sheldon var. minus Wollenweber



***(G) Curvularia lunata* (Walker) Boedijn**



***(H) Botryodiplodia theobromae* Patouillard**

FIGURE 3: SHOWS DIFFERENT FUNGAL SPECIES ISOLATED FROM SOIL TREATED WITH FLUORIDE

IV. CONCLUSION

From the field experiments, it is clear that fluoride reduce the growth, metabolism and yield of crops but inoculation of vermicompost, compost and bacterial consortia can make the plant more resistant as well as such organic resources also capable to maintain the soil health and biodiversity. In India, we have several indigenous natural inputs which can be use judiciously under field condition and they can be a potent tool for reduction in the level of contaminants. It was observed from such studies that the use of treatment combinations (vermicompost +compost+ bacterial consortium) was able to reduce the fluoride content in soil and plants growing upon there. Therefore, such treatment combination if used, have a positive role in combating fluoride level under such agroclimatic field conditions, Such low cost agro technology needs further experimentations with diverse crops under diverse agro-climatic condition for supplying the knowledge to the farmer's level. After studies on several agroecological conditions, in a vast country like India this technology could be released to farming community for the benefit of mankind as a whole.

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